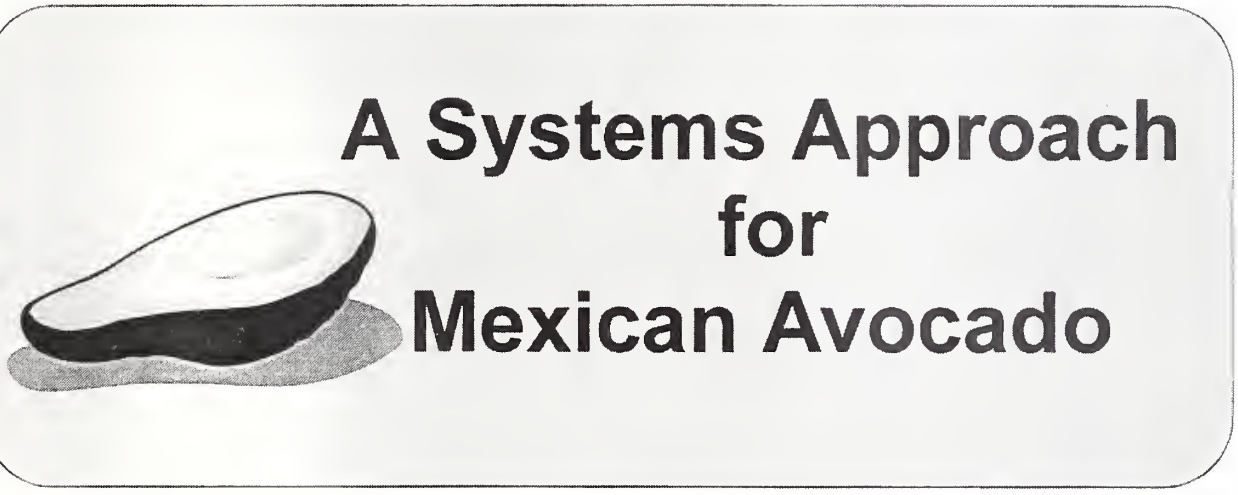
Risk Management Analysis



May 1995

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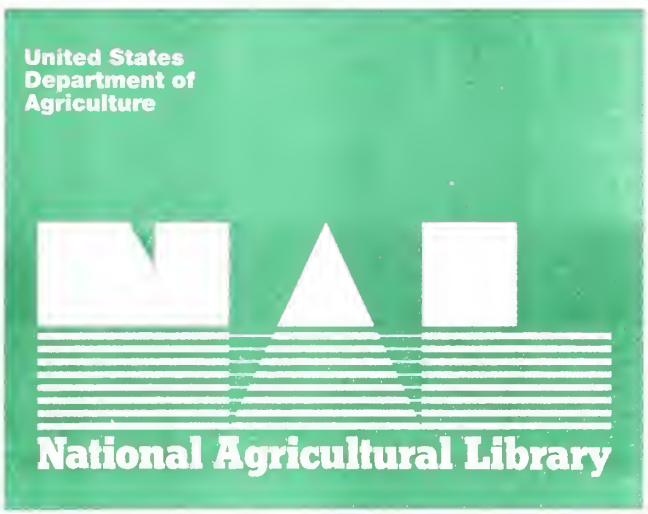
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CONTENTS

EXECUTIVE SUMMARY

Currently, Mexican avocados are prohibited into the United States (except for Alaska) because of the occurrence in Mexico of potentially harmful pests, including the small avocado seed weevils, large avocado seed weevil, avocado stem weevil, avocado seed moth, and three species of fruit flies. The weevils and moth, which are not known to occur in the United States, pose a potentially serious threat to the U.S. avocado industry. The fruit flies, on the other hand, are not considered serious pests of avocados but pose a significant economic threat to other U.S. fruit crops such as citrus. In addition, concerns also exist with regard to a pest group referred to as hitchhikers and other non-target pests.

In 1994, the Government of Mexico developed and submitted a proposal for shipping Hass variety avocadoes from certain approved orchards in the State of Michoacan to the Northeastern United States. Mexico's proposal, which was subsequently augmented by APHIS and referred to as the "systems" approach, utilizes a series of risk mitigation measures which individually and cumulatively reduce the risk of the pests indicated above. The system consists of nine safeguards or risk mitigation steps which operate in a sequential fashion to progressively reduce these pest risks to an insignificant level.

The nine mitigation measures, or the individual components of the systems approach, include: field surveys, trappings and field bait treatments, field sanitation practices, host resistance, post-harvest safeguards, winter shipping, packinghouse inspections, port-of-arrival inspection, and limited U.S. distribution.

This report examines Mexico's proposed approach (as augmented by APHIS), analyzing the risk reduction potential of each mitigation measure in the system, to determine whether Hass variety avocadoes imported into the United States under this system could occur without presenting a significant risk to U.S. agriculture. The analysis was conducted by a group of APHIS scientists, referred to in the report as the expert team. The estimates, generated by the expert team, regarding the risk reduction potential for each mitigative procedure (expressed as a percent reduction) is based on: pest survey data from Mexico; on-site reviews of the Mexican avocado research and visits to the production areas in Mexico; published scientific reports concerning pests associated with Mexican avocados; data from the weevil field surveys, fruit fly trappings, and packinghouse fruit cuttings; the known efficacy of the various risk mitigation procedures; input from USDA-Agricultural Research Service (ARS) scientists; USDA-APHIS pest interception data; input from U.S.industry and other groups; and many years of quarantine experience in managing similar commodities which present similar risks.

Nine Mitigation Measures

The nine mitigation measures which are elements of the systems approach are described below:

- Field Surveys

Surveys will be conducted in all export orchards and municipalities to determine freedom from seed pests and stem weevil. Surveys (i.e., visual inspection, fruit cutting, and branch shaking) would be conducted in areas which include wild and backyard fruit as well as commercial orchards. Surveys to detect target pests, conducted under Mexico and APHIS oversight, will result in an orchard either being approved or denied certification for export.

- Trapping and Field Treatments

The objective of fruit fly trapping is to monitor the fruit fly population levels throughout the entire year in the export orchards. Trapping protocols (i.e., trapping densities) will be based on other successful trapping programs for monitoring fruit fly population levels. If one or more fruit flies are found, the area is treated with malathion bait spray to eliminate or suppress the fruit fly population as necessary.

- Field Sanitation

Field sanitation practices (i.e., removing fallen fruit, branch pruning, and dead branch removal) help maintain healthy orchards, thereby reducing the chances of weevils becoming established as well as fruit being attacked by fruit flies. Specifically, fallen fruit must be picked up on a periodic basis and cannot be packed with export fruit. Fallen fruit may be overripe or damaged and therefore poses a higher risk of fruit fly and weevil infestation.

- Host Resistance

Exports will be limited to Hass variety avocado from approved orchards in four municipalities in Michoacan. USDA interception records indicate that avocados in general are poor hosts to fruit flies. Furthermore, forced infestation studies in the field show that Hass avocado attached to the tree is not a preferred *Anastrepha* host.

- Post-Harvest Safeguards

Avocados in trucks being shipped from the orchard to the packinghouse will be required to be tarped/enclosed to prevent fruit fly attack. At the packinghouse, protection against fruit flies and other pests will be ensured by using appropriate screen mesh to prevent the entry of all target pests as well as a double door system to control exit/entrance areas. Mexico and APHIS supervision will ensure that requirements are met, lots are not mixed, and all avocados originate from certified orchards.

- Winter Shipping Only

Shipping will only occur during the November-February season, thus limiting imports to the late fall and winter months when cooler temperatures in the production areas result in lower fruit fly and other pest activity. Moreover, allowing imports only during the winter months further decreases the risk of pest escape and survival. The potential for colonization of avocado pests during winter months in the United States is reduced even in most southern locations because of cold temperatures and/or lack of suitable host material.

- Packinghouse Inspection & Fruit Cutting

Inspection and sampling at the packinghouse is an additional mitigation measure for seed pests, stem weevils, and fruit flies. APHIS oversight and monitoring would occur at this step in the process. Positive pest detections at this stage will result in the shipment losing its export eligibility and possibly other measures depending on the pest species.

- Port-of-Arrival Inspection

These inspections include sampling (fruit cutting) and serve to verify accurate documentation, including that the: shipment is from a certified orchard, proper phytosanitary certificate is present, limited distribution statement appears on boxes, and shipment is consigned to a State where distribution is allowed.

- Limited U.S. Distribution

Avocado imports would be limited to the 19 Northeastern States and the District of Colombia. If any pests were to accompany a shipment and escape into the environment, they would not survive because of the harsh winter climate and the lack of suitable host material.

Analysis

- Fruit Flies

The systems approach has the total effect of greatly reducing the *Anastrepha* risk. Each of the nine mitigation measures independently reduce the risk for *Anastrepha* fruit flies. Two of these measures, host resistance and limited U.S. distribution, are judged as causing extensive reduction of the potential risk (95 to 99 percent reduction) for this group. In addition, each of the other seven mitigation measures are estimated to provide moderate reductions. In totality, the post-mitigated risk of *Anastrepha* is insignificant.

- Avocado Seed Pests

The effects of the mitigation measures are judged to be the same for the three avocado seed pests (i.e., small and large avocado seed weevil and avocado seed moth). The risk for the small avocado weevils may be slightly higher because, unlike the other two groups, they are known to occur in the State of Michoacan in an area near the four proposed exporting municipalities.

The non-mitigated pest risk of these groups is assumed to be moderate compared to the *Anastrepha* group because of a much lower colonization potential. In Mexico, their distribution is limited by factors other than host availability. For example, the seed moth seems to be restricted to the more tropical regions along Mexico's coastlines while the seed weevils tend to be found in the highlands. None of these pests groups occur in Mexico's commercial and backyard avocado growing areas. Also, there is no evidence that the long distance movement of avocado fruit has caused outbreaks of these quarantine pests in other areas of the world.

Two of the mitigation measures, field surveys and limited U.S. distribution, extensively reduce the risk (by 80 to 99 percent) of these pest groups and three other mitigation measures provide additional reductions. Overall, the post-mitigated risk of the avocado seed pests is insignificant.

- Avocado Stem Weevil

The pest risk before mitigation for the avocado stem weevil is about the same as the risk associated with seed pests because of similarities in both the economic impacts and colonization potentials. Three of the mitigation measures (field survey, sanitation, and limited distribution) each reduce the risk by about 90 percent each and two other measures reduce the risk by a moderate degree. The totality of the six mitigation

measures would reduce the risk of avocado stem weevil to an insignificant level.

- Hitchhikers and Other Pests

The risk from this group is low compared to any of the target pests. This risk would be relatively the same (before mitigation) as the risk for the hundreds of other fresh agricultural commodities that are imported or exported from the United States with port-of-entry inspection alone as the only mitigating factor. Since all nine mitigation measures reduce the risk to some degree, the risk after mitigation from hitchhikers would be extremely low.

Risk Reduction in the Aggregate

The expert team concludes that the nine risk mitigation steps operate in a sequential fashion to progressively reduce the pest risks, associated with Hass avocados, to an insignificant level. The systems approach operates like a fail-safe system in that redundant safeguards are built into the process. That is, if one mitigating measure fails, other safeguards are in place to ensure that the risk continues to be effectively reduced and managed. If pest detections or irregularities are detected at any stage of the system, the shipment loses its eligibility and appropriate actions are taken to ensure compliance.

The low risk associated with the importation of Hass avocados, particularly under a systems approach, is supported by the experience of other countries which import Mexican avocados. For example, Japanese inspection data show that from 1992 to 1994 Mexico shipped 5,230,114 kg. of Hass avocado fruit to Japan (representing about 260 forty-foot sea containers or about 14 million fruit). Japanese agricultural officials inspected 16,000 kg. (or about 50,000 fruits) and reported finding none of the target pests of concern to the United States. It is important to note that these avocado exports to Japan occur under Mexico's current export program which requires only some of the mitigating measures discussed in this report. Furthermore, avocado exports to Japan are not monitored by on-site personnel from the importing country. Instead, the importing country requires only port-of-arrival inspection. In contrast, the proposed APHIS program would require full utilization of all nine safeguards assessed in this report and involve direct APHIS oversight in Mexico (e.g., monitoring of the pest surveys and packinghouse inspections).

I. INTRODUCTION

A. Objective

In 1994, the Government of Mexico submitted a proposal for shipping Hass variety avocadoes from certain approved orchards in the State of Michoacan (Periban, Salvador Escalante, Uruapan, and Tancitaro) to the Northeastern United States. Mexico's proposal, which was subsequently augmented by APHIS with additional safeguards and is referred to as a systems approach, utilizes a series of risk mitigation measures which individually and cumulatively reduce the pest risk associated with avocados.

The systems approach consists of nine safeguards or risk mitigation steps which operate in a sequential fashion to progressively reduce the pest risks associated with avocados. The nine mitigation measures include: field surveys, trappings and field bait treatments, field sanitation practices, host resistance, post-harvest safeguards, winter shipping, packinghouse inspections, port-of-arrival inspection, and limited U.S. distribution. This report analyses the effectiveness (i.e., estimating the risk reduction potential) of each mitigation measure in the system to determine whether Hass variety avocadoes imported into the United States, under this comprehensive system, could occur without presenting a significant risk to U.S. agriculture.

B. Background

Avocado fruit has been prohibited from Mexico by the U.S. Department of Agriculture (USDA) since 1914. Avocado was originally prohibited because of the presence of avocado seed weevils (*Heilipus laun*) in Mexico. Subsequently, other agricultural pests of quarantine concern were identified by USDA as presenting a pest threat.

Currently, Mexican avocados are prohibited into the United States (except for Alaska) because of the occurrence in Mexico of:

- Small avocado seed weevils (*Conotrachelus perseae and C. aguacatae)*
- Large avocado seed weevil (*Heilipus laun*)
- Avocado stem weevil (*Copturus aguacatae*)
- Avocado seed moth (*Stenoma catenifer*)
- Fruit flies (*Anastrepha ludens, A. serpentina* and *A. striata*)

The weevils and moth do not occur in the United States and pose a potentially serious threat to the U.S. avocado industry. One of the fruit flies, the Mexican fruit fly (*A. ludens*), occurs periodically only in the Lower Rio Grande Valley of Texas in the United States where it is under quarantine control. The other two fruit flies (*A. serpentina* and *A. striata*) do not occur in the United States. The fruit flies are not considered serious pests of avocados but do pose a significant economic threat to other U.S. fruit crops such as citrus.

Economic impact studies have been completed by the Animal and Plant Health Inspection Service (APHIS) for the Mexican fruit fly and two of the avocado weevils (the small avocado seed weevil and the avocado stem weevil). The Mexican fruit fly study estimated an approximate annual loss of $1.44 billion if this pest were to become permanently established in six Southern U.S. States (Florida, Georgia, Louisiana, Texas, Arizona, and California). The second study indicated that if either of the avocado weevils became generally established in the avocado growing areas of California alone, estimated losses per year would total $123.6 million. These reports are cited below.

As indicated above, fresh Mexican avocado fruit are currently prohibited (except into Alaska) because of the eight listed pests. These pests are known to feed within the avocado fruit. If avocado fruit were not carefully regulated they could become established in the United States. In this document, the eight pests will be referred to as the target pests. Other pests are associated with avocados in Mexico but are either not considered quarantine pests (e.g., widespread in the United States), not associated with the avocado fruit, or can be excluded by routine inspection of the fruit on the U.S. borders. More details on the pests associated with Mexican avocados are given in the recent assessment attached to this document (Attachments #1 and #2).

C. Resources

Information from a variety of sources was used for this analysis. The primary sources includes:

- Proposed Work Plan for the Exportation of Hass variety Avocado from Mexico to the United States; Direccion General de Sanidad Vegetal (DGVS); July 1994.

- Risk Assessment, attachment #1 Entomology and attachment #2 Pathology; USDA, APHIS; 1992.

- Published literature concerning pests associated with Mexican avocados - listed as references in the attached risk assessment.

- Status of "Hass" Avocado as Host of Three Species of Fruit Flies of the *Anastrepha* Genus (Diptera:Tephritidae) under Induced Laboratory and Field Conditions and also under Natural Field Conditions; DGSV; May 1994.

- An Oversight Review Group, consisting of ARS and APHIS scientists made 4 site visits to Mexico between July 1993 and January 1994. In addition, the Phytosanitary Work Group, which consists of SV and APHIS plant health, made a site visit to the production areas in 1992.

- ARS Review and Comments of Status of Hass Avocado as Host of Three Species of Fruit Flies of Genus *Anastrepha* paper; USDA; July 1994.

- Preliminary Scientific Evaluation of Mexican Research Report and Proposed Workplan for the Export of Hass Variety Avocado from Mexico to the U.S.; California Avocado Commission; August 1994.

- Reports and records of weevil field surveys, fruit fly trappings, and packinghouse fruit cutting; DGSV, 1985-1994.

- Pest interception records; USDA, APHIS; 1985-1994.

- Economic Impact of the Establishment of Mexican Fruit Fly in the United States; USDA, APHIS; September 1992.

- Potential Economic Impacts of an Avocado Weevil Infestation in California; USDA, APHIS; August 1993.

- Public comments received between November 15, 1994 and January 3, 1995, solicited from the Advance Notice of Proposed Rulemaking, Federal Register, Vol. 59, No. 219 (Docket number 94-116-1).

D. Methodology

The analysis in this report was conducted by a team of plant health, quarantine, and risk management professionals from APHIS. These professionals, also authors of this report, are referred to in this document as the expert team. Collectively, the professionals on the expert team have approximately 87 years of quarantine and regulatory experience. This expert team also benefitted from scientific input provided by USDA's Agricultural Research Service (ARS).

Besides, the many years of quarantine experience, the key sources of scientific information and data used in this analysis include: (1) a number of site visits by APHIS and ARS scientists to the producing areas in Mexico; (2) findings from field and laboratory research; (3) extensive review of the scientific literature; and (4) input from various public groups, including U.S. industry.

The expert team analyzed each element of the systems approach as proposed by Mexico. These elements include: field surveys, trapping and field bait treatments, field sanitation, host resistance, post-harvest safeguards, winter shipping, packinghouse inspections, port-of-arrival inspection, and limited U.S. distribution. In addition to analyzing and estimating the risk reduction potential of each element, the expert team identified additional requirements and conditions that would further ensure the safe importation of Mexican avocados. The Table 1 matrix identifies the pests or pest groups that are potentially affected by each of the mitigation measures.

In addition to evaluating the target pests listed in the introduction, the expert team also assessed the impact of the risk mitigation measures on a pest group referred to as "hitchhikers and other pests." This particular group includes hitchhiking plant pests and other plant pests not previously identified as fruit pests of avocado.

Based on existing scientific evidence regarding avocado pests, regulatory experience and practice with similar horticultural commodities, and cumulative expert opinion, an estimate was developed regarding the extent to which risk is reduced by each mitigation measure as applied to each specific pests of concern. The estimate is expressed in terms of a range (a low and a high value). A wide range indicates a greater degree of uncertainty. The Table 3 matrix was developed to show the estimated risk reduction for each pest group and to illustrate the effects of the systems approach on reducing the total risk.

The conclusion provides the expert group's subjective estimate of the overall risk based on the independent and cumulative effect of each mitigation measure.

E. Mitigation Measures

Field Surveys

Surveys are to be conducted in all export orchards and municipalities to determine freedom from seed and stem weevils. Sampling would be carried out under the direct supervision of Sanidad Vegetal with monitoring by USDA/APHIS. These surveys would be conducted in areas which include wild and backyard fruit as well as commercial orchards. Commercial orchards adjacent or in close proximity to orchards registered for export would also be included in surveys. The survey will include visual inspection, fruit cutting, and branch shaking. Surveys to detect target pests (conducted at appropriate times during the growing season) will result in an orchard either being approved or denied orchard certification for export. The municipalities must be free from targeted seed pests to the extent that can be determined by survey. A number of hectares will be surveyed that will give a 95 percent confidence level that an infestation rate of 1 percent or more would be detected. This would be 300 hectares for municipalities with large production areas such as the four municipalities included in the Mexican proposal.

Trapping and Field Treatments

The objective of fruit fly trapping is to monitor the fruit fly population levels throughout the entire year in the export orchards. Trapping at a level of 1 trap per 10 hectares is an acceptable trapping density (based on other successful Anastrepha trapping programs, see Table 2) for monitoring fruit fly population levels. If a fruit fly is detected, then the trapping level would increase to 10 traps in the surrounding 50 hectares. If additional flies are found within a month of the initial find, and within 260 hectares of the initial find, then export could only continue under malathion bait treatments of the orchards involved (see Table 2). The purpose of this action is to lower the fruit fly population level in the export areas thereby reducing pest population pressure.

Medfly trapping is required at the level of one trap per 1 to 4 square miles. Although medfly outbreaks have occurred only in southern Mexico, this is a safety measure designed to detect new outbreaks of medfly.

Field Sanitation

The purpose of field sanitation is to maintain healthy orchards, which will decrease the chances of weevil establishment and fruit fly attack. Specifically, fallen fruit must be picked up on a periodic basis and cannot be packed with export fruit. Fallen fruit is often overripe or damaged and therefore pose a higher risk from fruit fly attack and weevil infestation. Pruning and dead branch removal will help prevent weevil attack, specifically the stem weevil (*Copturus aguacate*).

Host Resistance

Resistance of Hass avocadoes to the endemic fruit flies is known from previous U.S. and Mexico interception records and the lack of detections of *Anastrepha* fruit flies in Hass avocados (USDA/APHIS pest interception records). Exports will be limited to Hass variety avocado from approved areas in Michoacan. The Hass variety is easily distinguished from other varieties of avocados and represents 90 percent of all avocado production in the state of Michoacan. APHIS records, along with Sanidad Vegetal's (SV) years of fruit cutting, show that fruit flies have not been intercepted in commercial shipments of avocado exports. Although Hass avocado was attacked by *Anastrepha* during forced infestation studies, prior interception records and field forced infestation studies have shown that Hass avocado attached to the tree is not a preferred *Anastrepha* host.

Post-harvest Safeguards

The safeguarding of avocado fruit is considered an important factor in protection against fruit fly attack. Also, there is concern that other pests, such as hitchhikers, could be introduced in packing houses. Avocados in trucks being shipped from the orchard to the packinghouse will be required to be tarped/enclosed to prevent fruit fly attack. This measure would require timely movement from orchard to packinghouse and that the packinghouse be safeguarded to prevent the entry of pests. Protection against fruit flies and other pests will be accomplished by using screen with openings no more than 1.6 mm per inch to protect all openings to the outside. This screen size is adequate to prevent the entry of all target pests. Also, a double door system is required for exit/entrance areas to the packing facilities. Supervision by SV and APHIS will ensure that requirements are met, lots are not mixed, and all avocados originate from certified orchards.

Winter Shipping Only

Shipping only during the November-February season will limit imports to the late fall and winter months when cooler temperatures in the production area result in lower fruit fly and other pest activity (i.e., breeding and feeding). Reduced fruit fly activity in the production area during harvest times would decrease the potential for fruit to be attacked by fruit flies. In addition, avocado fruit is typically harvested in the morning when temperatures are cooler and fruit fly activity is reduced, thereby further reducing the potential for fruit flies attacking harvested fruit.

If an incidental pest was moved on an avocado shipment, allowing import only during the winter months would further decrease the risk of pest escape and survival. The potential for colonization of avocado pests during winter months in the United States is reduced even in most southern locations because host material is unavailable.

Any tropical pest that escapes into the Northeastern United States (the allowable distribution area) during the winter months would have an extremely low chance of survival and establishment because of freezing temperatures and the lack of suitable host material.

Packinghouse Inspection & Fruit Cutting

Inspection at the packinghouse is an additional mitigation measure. APHIS oversight and monitoring would occur at this step in the process. Pest detections at this stage would result in the shipments losing its eligibility for export and other appropriate action being taken.

Port-of-Arrival Inspection

This inspection serves as another redundant safeguard—i.e., goes over and beyond the necessary steps in order to compensate for a failure that may occur in an preceding measure—for fruit flies, seed pests, and stem weevils. Sample size will vary, but will include at least 30 boxes sampled and/or 30 fruit cut per shipment. This inspection serves to check paperwork, verify that the shipment is from a certified orchard, and the valid Phytosanitary certificate is present. Furthermore, inspections would include verification that the limited distribution statement appears on boxes and that the shipment is consigned to a State where distribution is allowed. Customs in-bond papers would be reviewed to ensure that shipments are only consigned to locations within the authorized distribution area.

Limited U.S. Distribution

Limiting imports of avocados to the Northeastern States and the District of Colombia serves as another redundant safeguard in the system. If any pests were to accompany a shipment and escape into the environment, they would not survive because of the harsh winter climate and the lack of suitable host material.

All 19 states, where distribution is allowed, are in the temperate climate zone. The pests of concern are tropical fruit and tree pests which, lacking adequate host material, would not be able to survive. Even assuming that some of the product leaves the allowable distribution zone with travelers, the risk of pest establishment is negligible.

II. ANALYSIS

A. Systems Approach Matrix

Table 1- Systems Approach: Mexican Avocado

Risk Mitigation Measures	Identifying Potential Mitigation Measures per Pest Group					
	Fruit flies: *Anastrepha spp.*	**Small avocado seed weevils:** *Conotrachelus spp.*	**Avocado stem weevil:** *Copturus aguacatae*	**Large avocado seed weevil:** *Heilipus lauri*	**Avocado seed moth:** *Stenoma catenifer*	**Hitchhikers and other pests**
Field surveys	✔	✔	✔	✔	✔	✔
Trapping and field treatments	✔					✔
Field sanitation	✔	✔	✔	✔	✔	✔
Host resistance	✔					
Post-harvest safeguards	✔					✔
Winter shipping only	✔					✔
Packinghouse inspection and fruit cutting	✔	✔	✔	✔	✔	✔
Port-of-arrival inspection	✔	✔	✔	✔	✔	✔
Limited U.S. distribution	✔	✔	✔	✔	✔	✔

B. Risk Analysis

1. *Anastrepha* Fruit Flies

Field Surveys

The risk reduction for this measure is compared to the risk associated with fruit from any location within Mexico where no survey requirements are in place. The risk reduction from this mitigation measure for *Anastrepha* would result from the fruit cutting required in the annual field surveys. Although not used as the primary method for excluding fruit flies by APHIS, second and third instars of fruit fly larvae can be detected by fruit cutting. Depending on the size of the orchards and the age of the trees, large numbers of fruit would be cut. In general, more than 1,000 fruit would be cut per orchard and many thousands would be cut for large orchards. Most of the fruit cutting would be fruit from the ground. Cutting of a random sample of 1,200 fruit per orchard would give a 95 percent statistical certainty of finding a detectable infestation at or above the .25 of 1 percent level. Fruit cutting provides evidence about infestation in the field and not at the time of shipment. Reviewing survey records from 1991 to the present, and considering a large degree of uncertainty caused by human error, the expert team estimates that this measure reduces the pest risk between 40 and 60 percent.

Trapping and Field Treatments

Recent trapping data from export areas indicate that fruit fly populations are low. Mitigation from this measure occurs as a result of trapping and treatment conducted during the growing season during the year of export. The estimated reduction in potential risk due to this element is compared to the risk from Mexican avocados from any location within Mexico with no trapping requirements. On-site review by APHIS scientists of the four previously mentioned municipalities indicate that the quality of the trapping programs varied. APHIS oversight will ensure greater uniformity and quality. Similar risk mitigation measures are used in the United States to reduce the risk of fruit flies in fruit shipments. A similar program is used to allow the export of Florida citrus from areas infested with the Caribbean fruit fly. Both programs use McPhail traps and bait treatments and are concerned with a non-preferred host of the target pest. Other similar programs include the U.S. citrus certification program in the Lower Rio Grande Valley of Texas for Mexican fruit flies and the existing program which allows for the movement of California fruit under certain conditions without post-harvest treatment from quarantine areas associated with exotic fruit fly outbreaks in California. See Table 2 for a comparison with other programs.

Given the above, the estimated risk reduction afforded by trapping for *Anastrepha* is between 55 and 75 percent.

Table 2 - Comparing *Anastrepha* Programs

Program	Routine Trapping Density	Other Mitigating Practices / Conditions	Emergency Response to Captures
Proposed Mexican Avocado	1 trap / 10 hectares (approximately 25 traps per square mile)	♦Low fruit fly population ♦Poor condition for fruit flies ♦Low host preference (possible non-host)	♦One fly - 10 addition traps in 1/4 mile radius ♦Second fly within 30 days in 1 square mile - bait sprays
Sonora Free Zone	25 to 30 traps per square mile	♦Free fly status ♦Regulatory quarantines	♦One fly - 81 square miles trapping zone ♦Second fly within 30 days in 5 miles - bait sprays
U.S. National detection protocol	High Risk areas 5 traps per square mile Marginal area 1 trap per 5 to 10 square miles	♦Exotic status of Mexican fruit fly ♦Regulatory quarantines	♦One fly per 81 square miles trapping zone ♦Second fly within 3 miles in one life cycle - various eradication responses possible
Rio Grande Valley Citrus	5 traps per square mile	♦Sterile fly releases ♦Extremely low population	♦One fly - 10 traps plus 200,000 steriles released per week within 1/4 mile radius ♦Second fly within block - bait spray or fumigation
Caribfly Florida -Low Risk-	2 traps per square mile in designated area, 5 traps per square mile in buffer	♦> 3 miles from preferred host ♦> 300 acres designated area ♦1 1/2 mile wide buffer ♦Low host preference	♦Matrix for determining response - actions vary from addition traps, fruit cutting, bait sprays or combination of these to suspension of protocol
Caribfly Florida -Moderate Risk-	15 traps per square mile	♦Routine bait spray ♦> 40 acres designated area ♦300 point wide buffer ♦Low host preference	♦Two flies - elimination from program

Field Sanitation

Risk reduction achieved by this measure is compared to known Mexican fruit fly host material grown in any location in Mexico without field sanitation requirements in place. The analysis group estimated a reduction of between 75 and 95 percent based on risk reduction caused by: a) the elimination of potential pest populations because of the removal of fallen fruit (potential breeding sites); and b) the reduction in the probability of potentially infested fruit from the ground being harvested for export. A recent SV study indicated that fruit not attached to the tree is a susceptible host, at least under laboratory conditions. No evidence exists to show that *Anastrepha* fruit flies have emerged from Hass avocado fruit, attached or unattached to the tree, except under laboratory conditions of fruit infested after harvest. It is known from studies of other species of fruit flies that infestation levels are reduced for fruit attached to the tree if fallen fruit are removed from the growing area. Good sanitation practices within the orchard would significantly reduce the risks of attracting fruit flies to the orchard.

Host Resistance

The estimate of potential risk reduction for this element is compared to the risk of exporting normal field (preferred) hosts of these fruit flies from Mexico. The following evidence was considered:

-- No historical evidence exists that these pests attack Hass avocados in nature. ARS scientists investigated the relationship between avocados and fruit flies in the 1950's in Mexico. The investigation found several locations where *Anastrepha* attacked non-improved Mexican forms of avocado and a few situations where improved Guatemala forms or hybrids were attacked. Hass was not commonly grown in Mexico during that time.

-- Although APHIS inspectors commonly seize large numbers of various types of avocado fruits carried by travelers from Mexico, *Anastrepha* is rarely found (see assessment). In recent years, hundreds of smuggled commercial lots of Hass avocados from Mexico have been seized at El Paso, Texas. Although several hundred interceptions of a curculinoid larvae (likely to be the avocado stem weevil) were made, no fruit flies were intercepted.

-- Recent studies by SV found no larvae from Hass avocados harvested from the ground nor were they able to force infest fruit while on the tree. The forced infestation study in the laboratory, however, indicates that Hass avocado fruit is a susceptible host under certain post-harvest conditions.

-- Between 1992 and 1994, Japanese agricultural officials inspected about 50,000 Mexican Hass avocados and did not find any fruit fly larvae.

-- Since 1988, SV has cut over one million Hass avocados during its packinghouse inspections and reported no fruit fly finds. Additional cutting of fruit from the trees and ground has occurred as part of the field surveys, also with negative findings.

-- ARS scientists have concluded: "The overall comparison of laboratory and field cage Hass avocados demonstrated (in agreement with other studies of avocados) that fruit attached to the tree shows considerable resistance to fruit fly attack and this resistance coupled with other components of a systems approach has great promise as a quarantine procedure."

The expert team estimated a reduction in risk of between 95 and 99 percent for this element.

Post-harvest Safeguards

The post-harvest safeguards were specifically designed for fruit flies. No empirical evidence was found that indicates that *Anastrepha* fruit flies would attack host material during the harvesting, packing, and transiting activities of commercial fruit without safeguards. The expert team estimated a reduction of between 60 and 90 percent of post-harvest attack, assuming that this risk exists. The team believes this safeguard is required because of the results of SV forced laboratory cage test.

Winter Shipping Only

The majority of reduction in pest risk from this element would be from limited adult fruit fly activities under colder temperatures in the growing areas in Mexico. *Anastrepha spp.*, including the Mexican fruit fly, stop or reduce mating and oviposition activities when temperatures fall below 70 degrees Fahrenheit. Generally, temperatures during the winter months in the proposed growing area are below 70 degrees Fahrenheit (according to unpublished ARS studies in Texas).

Secondly, the colonization potential of fruit flies in Southern U.S. States, except southern Florida, is limited during the winter months because of sub-optimal temperatures and/or lack of host material.

The analyst group estimated a reduction in risk of between 60 and 90 percent compared to the same produce harvested and shipped at anytime of the year.

Packinghouse Inspection and Fruit Cutting

Based on the 250 randomly selected fruit sample (per lot), and assuming that the pests would be found by the cutting process, a 95 percent certainty exists that an infestation at or above the 1 percent level would be detected. The expert team believes that good quality control is difficult to obtain for a process that depends on inspection and that first instar fruit fly larvae can be easily missed. For this reason the team estimated that this procedure in the system reduces the pest risk between 25 and 40 percent compared to fruit not receiving packinghouse cutting and inspection.

Port-of-arrival Inspection

Due to small sample sizes taken by inspectors at U.S. ports of entry, it is unlikely that a low-level infestation in a given shipment would be detected. This inspection completed for all shipments during the year, and with negative results, would act as an independent check on the overall effectiveness of the program. An important benefit of this particular step in the system is to validate the documentation that accompanies the shipment—measures that help ensure that shipments meet U.S. entry requirements. For example, this port-of-arrival inspection helps: 1) reduce, to a great degree, the risk of non-program fruit entering the U.S. in large amounts, 2) ensure that the fruit entering is indeed the Hass variety, and 3) ensure that the fruit is destined to low-risk states. The expert group estimates that this measure reduces risk between 50 and 70 percent compared to shipments that are not monitored at U.S. borders.

Limited U.S. Distribution

Anastrepha fruit flies would not become established in the Northeastern United States because of both climate and host factors. The eight previously mentioned measures ensure that shipments arriving in the Northeast would be free of target pests. If the earlier safeguards fail, then limited U.S. distribution provides an additional measure of safety. A review team consisting of APHIS and ARS scientists observed, during site visits to Mexico to review Mexico's existing export program for shipping avocadoes to Japan, Canada, and Europe, that shipments, even without additional safeguards, are free of target pests or are infested at low levels.

The expert team assumes that a certain amount of avocado fruit may inadvertently be moved to susceptible areas by travelers. The amount would likely be one to a few fruit each, even though avocado fruit are not commonly carried by the traveling public like apples and bananas. There is a small possibility that part of or a whole shipment could be periodically diverted to Southern States. Since California Hass would be out of season, detection would be fairly easy. USDA' Agricultural Marketing Service (AMS), Fruit and Vegetable Division will notify APHIS of Mexican avocado fruit found at terminal

markets in prohibited states. An estimate of between 95 and 99 percent was developed regarding the degree of reduction in risk compared to shipments that are allowed distribution into all parts of the United States.

Summary for *Anastrepha* Fruit Flies

The systems approach has the total effect of greatly reducing the *Anastrepha* risk. Each of the nine mitigation measures independently reduce the risk for *Anastrepha* fruit flies. Two of these measures, host resistance and limited U.S. distribution, are judged as causing extensive reduction of the potential risk for this group. In addition, all of the other elements are assumed to give at least moderate reduction. In totality, the post-mitigated risk is insignificant.

2. Avocado Seed Pests

The risk of small and large avocado seed weevils and the avocado seed moth are assessed together because of the similar impacts the mitigation measures on these seed pests.

Field Surveys

Small seed weevils are not known to occur in the exporting municipalities and the large seed weevil and seed moth do not occur in the State of Michoacan. Nonetheless, field surveys are designed to detect the seed pests and stem weevil. Furthermore, APHIS oversight will enhance the level of confidence that infestations of the above pests will be detected in export orchards.

Area freedom determinations for the seed pests will be based on annual surveys. Surveys will include all orchards that will export fruit to the United States and other orchards that are generally spread over the production area of designated municipalities. The number of hectares surveyed per municipality will be based on the total production hectares in the municipalities and that which will give a 95 percent confidence level of detecting a 1 percent or greater infestation rate.

For the municipalities with large production, including the four in question, the number of hectares that need to be surveyed would be 300 per municipality. Additional backyard and wild trees will be required to be surveyed. Findings of the review group (consisting of APHIS and ARS scientists) which visited the production areas in Mexico and negative results from the previous season's survey work indicate that these areas are free of the avocado seed pests. Given the above, an estimate of between 95 and 99 percent was developed for the degree of risk reduction caused by the survey for these pests.

Field Sanitation

Good field sanitation reduces the general pest population for most crops. The removal of fallen fruit from the avocado orchard is also expected to reduces the probability of new outbreak for avocado seed pest because of the tendency of infested fruit to drop prematurely. The elimination of fallen fruit from the orchard eliminates the harvesting of the fallen fruit, thus reducing the probability of infested fruit getting into an export shipment from new or undetected outbreaks of the seed pests. The expert team estimated a reduction between 15 and 35 percent in the risk of shipments being infested compared to non-program orchards.

Packinghouse Inspection and Fruit Cutting

An estimate of 50 to 75 percent reduction in risk was developed based on the same evidence as discussed under the *Anastrepha* fruit fly section. The seed pest would be more readily detected by cutting because of size and the type of damage caused by the insect.

Port-of-Arrival Inspection

An estimate of 50 to 70 percent reduction in risk was developed based on the same evidence as discussed in the *Anastrepha* fruit fly section.

Limited U.S. Distribution

None of the avocado seed pests would become established in the Northeastern United States because of both climate and host factors. These pests are tropical or subtropical and host specific. The previously mentioned measures ensure that shipments arriving in the Northeast would be free of target pests. If an earlier safeguard fails, then limited U.S. distribution provides an additional safety measure. Observations made by APHIS and ARS scientists of Mexico's current program for exporting avocadoes to Japan, Canada, and Europe demonstrate that shipments, even without additional safeguards discussed here, are free of the avocado seed pests or are infested at extremely low levels. The expert team assumes that a certain amount of avocado fruit may inadvertently be moved to susceptible areas by travelers. The lot size would likely be one to a few fruit each. There is also a small possibility that part of or a whole shipment could be periodically diverted to Southern States. Since California Hass would be out of season, detection would be fairly easy. Given the above, and assuming fewer than 5 percent of the avocados shipped into the Northeast United States would be diverted to states outside the approved distribution area, the expert team estimated that this measure (i.e., limiting the distribution of avocado shipments) would reduce the risk of these target pests between 95 and 99 percent.

Summary for Avocado Seed Pests

The effects of the nine mitigation measures are judged to be the same for the three pest groups (i.e., small and large avocado seed weevil and avocado seed moth). The risk for the small avocado weevils may be slightly higher because, unlike the other two groups, they are known to occur in the State of Michoacan in an area near the four proposed exporting municipalities.

The non-mitigated pest risk of these groups is assumed to be moderate compared to the *Anastrepha* group because of a much lower colonization potential. In Mexico, their distribution is limited by factors other than host availability. For example, the seed moth seems to be restricted to the more tropical regions along Mexico's coastlines and the seed weevils tend to be found in the highlands. None of these pests groups occur in Mexico's commercial and backyard avocado growing areas. Also, there is no evidence that the long distance movement of avocado fruit has caused outbreaks of these quarantine pests in other areas of the world.

Two of the mitigation measures, field surveys (including historical data) and limited U.S. distribution, give extensive reduction for these groups and three others give some reduction. Overall, the post-mitigated risk is insignificant.

3. Avocado Stem Weevil

Field Survey

Avocado stem weevils can easily be detected by visual inspection for stem damage in the orchard. The presence of a white exudate on the stem and fruit as a result of larvae tunneling facilitates detection. In addition, branch shaking provides a means to detect adults. This has been confirmed by field observation by APHIS. The pest is known to occur at low population levels in areas near some of the export orchards. An estimate of between 80 and 95 percent reduction in risk was developed as compared to shipments of export quality avocadoes from non-program orchards in Mexico.

Field Sanitation

High populations of stem weevils are associated with poor sanitation, trees under stress, and areas with more tropical climates (lower altitudes) than the export orchards (Muniz, 1959). This has been confirmed by field observation by APHIS. Program requirements for good sanitation, including pruning and dead tree removal would reduce the risk of infested fruit in shipments of export fruit by between 70 to 90 percent.

Packinghouse Inspection and Fruit Cutting

The amount of risk reduction provided by this mitigation measure is similar to the estimate for fruit flies (25 to 40 percent) and avocado seed pests (50 to 75 percent). The expert team estimated that risk reduction for the stem pest is between 40 and 60 percent. The small size of the stem weevil equals that of the fruit flies but a white exudate would be evident on the unwashed fruit thereby making the stem weevil more easily detectable.

Port-of-Arrival Inspection

The amount of risk reduction afforded by this step would be the same as for fruit flies and seed pests (based on the same rational), between 50 to 70 percent reduction in the risk of the shipment being infested.

Limited U.S. Distribution

The estimated reduction of risk of avocado stem weevil colonizing in the United States—similar to the case of fruit flies and the avocado seed pest—from shipments destined to Northern States is between 90 and 99 percent (fruit fly and seed pest estimates were 95 to 99 percent). The expert group assigned a lower value because less is known about the avocado stem weevil.

Summary for the Avocado Stem Weevil

The pest risk before mitigation for the avocado stem weevil is about the same as the risk associated with seed pests because of similarities in both the economic impacts and colonization potentials. An APHIS economic impact study indicated that if the stem weevil became established in the United States, the losses would be the same as the small seed weevils. The same factors that limit the colonization potential for the seed pests also apply to the avocado stem weevil. Three of the mitigation measures (field survey, sanitation, and limited distribution) each reduce the risk by about 90 percent each and two other measures reduce the risk to a moderate degree. The totality of the six mitigation measures would reduce the risk to an insignificant level.

4. Hitchhikers and Other Pests

Field Surveys

There is no reason to believe that the risk of "new" internal fruit pests is significant even before any mitigation. Nevertheless, fruit cutting, an integral component of field surveys, provides a significant degree of risk reduction because the cuttings can lead to the discovery of "new" internal pests. These "new" pests could be pests not known to occur in Mexico or pests not previously known to be associated with avocado fruit. Because of uncertainty, the expert team estimated that field surveys reduce overall risk by 40 to 75 percent.

Trapping and Field Treatments

The majority of risk from this group is from hitchhikers such as adults of various species of beetles, true bugs, or thrips, and not from internal pests including exotic fruit flies. However, the use of Jackson and McPhail traps will increase the probability of detection of medfly and other exotic fruit flies. Given the above, an estimate of between 3 to 20% reduction in risk was developed.

Field Sanitation

Good sanitation will reduce the general pest population for any crop. Hence, we must assume that some reduction in risk will occur for this pest group. However, from APHIS experiences with other preclearance programs, such as fruit from Chile, the majority of hitchhikers associated with imported shipments are associated with the packinghouse. Field sanitation procedures are estimated to reduce risk between 20 and 40 percent.

Post-Harvest Safeguards

As indicated above, the majority of hitchhikers found with commercial shipments of fruit are associated with the packinghouse process. Some of the packing of avocado fruit in Mexico occurs at night and many of the pests found in or around the packinghouse would be attracted by lights. The screening requirements would greatly reduce the risk from hitchhikers. The reduction in risk was estimated at between 40 to 60 percent for this element.

Winter Shipping Only

It can be assumed that some of the more tropical pests located in the growing areas will be absent or less common during the winter and that the colonization potential in the United States will be reduced during the colder months. In addition, a great reduction would occur in the number and types of night flying insects because of cool night temperatures. A reduction of between 50 to 75 percent was estimated for this requirement as compared to shipments arriving during any season.

Packinghouse Inspection and Fruit Cutting

Some reduction in risk from hitchhikers and other pests would occur as a result of inspections of the 250 fruit samples. However, the greatest amount risk reduction would occur as a result of SV and APHIS monitoring at the packinghouse to ensure that: 1) various post-harvest safeguards are in place, 2) shipping boxes are properly stored, and 3) trucks are free of hitchhiking pests before they are loaded. A 30 to 50 percent reduction in risk is estimated for hitchhikers.

Port-of-Arrival Inspection

The estimate of between 60 to 80 percent reduction was developed for professional inspection. This was larger for hitchhikers than for fruit flies and other fruit pests because these would normally be more easily detected than the internal pests.

Limited U.S. Distribution

The majority of pests that are likely to make up this group would be tropical or subtropical, and thus unable to establish themselves in the Northern United States. Their hosts are unlikely to be present in northern areas. The likelihood of a limited number of hitchhikers arriving and colonizing in the Southern United States as a result of a diverted shipment or fruit is minimal. A review of the pests previously introduced from Mexico into the United States indicated that the majority of these hitchhiking pests were not able to colonize in the Northern United States. Two exceptions are the Mexican bean beetle and the Russian wheat aphid (one a native of Mexico and the other an exotic). Because of some uncertainty regarding this pest group, the expert team estimated that the risk reduction is between 75 and 95 percent.

Summary for Hitchhikers and Other Pests

The risk from this group is low compared to any of the target pests. This risk would be relatively the same (before mitigation) as the risk for the hundreds of other fresh agricultural commodities that are imported or exported from the United States with inspection alone as the mitigating factor. Since all nine mitigation measures reduce the risk to some degree, the risk after mitigation from hitchhikers would be extremely low.

III. SUMMARY AND CONCLUSION

A. Risk Reduction Matrix

Table 3 - Systems Approach: Mexican Avocado

Risk Mitigation Measures	Reduction of Potential Pest Risk					
	Fruit Flies: *Anastrepha spp.*	**Small avocado seed weevils:** *Conotrachelus spp.*	**Avocado stem weevil:** *Copturus aguacatae*	**Large avocado seed weevil:** *Heilipus lauri*	**Avocado seed moth:** *Stenoma catenifer*	**Hitchhikers and other pests**
Field Surveys	40% to 60%	95% to 99%	80% to 95%	95% to 99%	95% to 99%	40% to 75%
Trapping and Field Treatments	55% to 75%	0	0	0	0	3% to 20%
Field Sanitation	75% to 95%	15% to 35%	70% to 90%	15% to 35%	15% to 35%	20% to 40%
Host Resistance	95% to 99.9%	0	0	0	0	0
Post-harvest Safeguards	60% to 90%	0	0	0	0	40% to 60%
Winter Shipping Only	60% to 90%	0	0	0	0	50% to 75%
Packing-house Inspection and Fruit Cutting	25% to 40%	50% to 75%	40% to 60%	50% to 75%	50% to 75%	30% to 50%
Port-of-Arrival Inspection	50% to 70%	50% to 70%	50% to 70%	50% to 75%	50% to 75%	60% to 80%
Limited U.S. Distribution	95% to 99%	95% to 99%	90% to 99%	95% to 99%	95% to 99%	75% to 95%

B. Conclusion

The systems approach proposed by Mexico and subsequently augmented by APHIS relies on a series of risk mitigation measures which individually and cumulatively reduce the risk of target pests (i.e., small seed weevils, large seed weevil, stem weevil, seed moth, and certain fruit flies) associated with Hass avocados. The system consists of nine safeguards or risk mitigation steps which operate in a sequential fashion to progressively reduce these pest risks to an insignificant level. The analysis contained in this report provides estimates, generated by an expert team of APHIS scientists, of the risk reduction that occurs at each stage of the system.

The analysis has shown that all nine mitigative measures effectively reduce the risks associated with the fruit flies of concern (see Table 3). For example, two measures—host resistance and limited U.S. distribution—each reduce the risk of fruit flies by 95 to 99 percent. In addition, the other seven mitigation measures (also shown in Table 3), operating independently and cumulatively, also substantially and progressively reduce the risks associated with fruit flies.

With regard to the other target pests, five of the nine mitigation measures effectively reduce the risk associated with seed weevils, stem weevil, and seed moth. The most effective safeguards in the system for reducing the risk of these particular pests include field surveys (risk reduced by 80 to 99 percent) and limited U.S. distribution (risk reduced by 95 to 99 percent). Two measures (packinghouse inspection/cuttings and port-of-arrival inspections) each provide significant protection by reducing risk by 40 to 75 percent. The fifth measure (field sanitation) also provides risk reduction effects, albeit to a less significant extent than the other measures.

The risk associated with hitchhiking pests and non-target pests are not any different than the risk represented by such pests on most agricultural products that are imported into and exported from the United States with port-of-entry inspections as the only requirement. Nonetheless, eight of the nine mitigative measures independently and collectively reduce the risk of these hitchhiking pests to an insignificant level.

The overall systems approach operates like a fail-safe system in that redundant safeguards are built into the process. That is, if one mitigating measure fails, other safeguards, with considerable risk reduction effects, exist to ensure that the risk is progressively reduced and managed. It should be underscored that if pest detections or irregularities are detected at any stage of the system, the shipment loses its eligibility and appropriate actions are taken to ensure compliance.

The low risk associated with the importation of Hass avocados under a systems approach is supported by the experience of other countries which import Mexican avocados. For example, Japanese inspection data show that from 1992 to 1994 Mexico shipped 5,230,114 kg. of Hass avocado fruit to Japan (representing about 260 forty-foot sea containers or about 14 million fruit). Japanese agricultural officials inspected 16,000 kg. (or about 50,000 fruits) and reported finding none of the target pests of concern to the United States. It is important to note that these avocado exports to Japan occur under Mexico's current export program which requires only some of the mitigating measures discussed in this report. Furthermore, avocado exports to Japan are not monitored by on-site personnel from the importing country. Instead, the importing country requires only port-of-arrival inspection. In contrast, the proposed APHIS program would require full utilization of all nine safeguards assessed in this report and involve APHIS oversight in Mexico (e.g., monitoring of the pest surveys and packinghouse inspections).

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ATTACHMENT #1 ENTOMOLOGY PERSEA MEXICO

A - The following quarantine pests are known to occur in Mexico, do not occur in the United States, and feed in the fruit or seed of Persea americana. Assessment concerning pests in this section is found in attachment 1 F.

1. Conotrachelus aguacatae — Curculionidae
   - TUNNELLING IN THE SEEDS OF Persea americana (ARELLANO, 1975).
   - OCCURS IN MEXICO (FAO, 1986)

2. Conotrachelus perseae — Curculionidae
   - LARVAE FEED IN SEED. ADULTS FEED ON LEAVES Persea americana (EBELING, 1959)
   - OCCURS IN MEXICO (FAO, 1986)

3. Copturus aguacatae — Curculionidae
   - TWIG BORER OF Persea americana (MACGREGOR, 1983)
   - OCCURS IN MEXICO (MACGREGOR, 1983)

4. Stenoma catenifer — Oecophoridae
   - FEEDS ON SEEDS IN FRUITS OF Persea americana (EBELING, 1959)
   - OCCURS IN MEXICO (MACGREGOR, 1983)

5. Heilipus lauri — Curculionidae
   - LARVAE FEED IN SEEDS. ADULTS FEED ON LEAVES Persea american (EBELING, 1959)
   - OCCURS IN MEXICO (MACGREGOR, 1983)

6. Anastrepha fraterculus — Tephritidae
   - FIELD INFESTATION OF Persea americana (NORRBOM, 1988)
   - OCCURS IN MEXICO (PNKTO)

7. Anastrepha ludens — Tephritidae
   - FIELD INFESTATION OF Persea americana (NORRBOM, 1988)
   - OCCURS IN MEXICO (STONE A, 1942)

8. Anastrepha serpentina — Tephritidae
   - FIELD INFESTATION OF Persea americana (NORRBOM, 1988)
   - OCCURS IN MEXICO (NORRBOM, 1988)

9. Anastrepha striata — Tephritidae
   - ATTACKS FRUIT OF Persea americana (BALLOU, 1936)
   - OCCURS IN MEXICO (STONE A, 1942)

B - Other quarantine pests attacking Persea in México but are not fruit pests.

1. Trioza anceps — Psyllidae
   - LEAF GALL OF Persea americana (MACGREGOR, 1983)
   - OCCURS IN MEXICO (MACGREGOR, 1983)

2. Apate monachus — Bostrichidae
   - ATTACKS Persea spp (PIERCE, 1917)
   - OCCURS IN MEXICO (MCGUIRE, 1967)

3. Diaprepes abbreviatus — Curculionidae
   - ATTACKS ROOT OF Persea americana (BENNETT, 1985)
   - OCCURS IN MEXICO (CALIF. DEPT. AGRI.)

4. Metcalfiella monogramma — Membracidae
   - ATTACKS TWIGS OF Persea americana (EBELING , 1959)
   - OCCURS IN MEXICO (EBELING, 1959)

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D - Previous Relevant Decisions:

On January 3, 1990, a request was denied to import avocados from Argentina into the U.S. because there were no approved treatments for Ceratitis capitata and Anastrepha spp.

On September 13, 1984, a request was denied to import avocados from Trinidad and Tobago in to the U.S. because there was no approved treatment for Anastrepha spp. (This decision was later amended to included Curacao.)

From Mexico:

1972 - Denied entry into all ports for lack of an approved treatment.
1975 - Approved for entry into northern ports from approved area of Michoacan. Rescinded in 1976 because larvae and adults of Conotrachelus perseae were found in the Uruapan area of Michoacan and the finding of larvae and adults of Conotrachelus aquacates and adulths of Conotrachelus sp. during survey in the State of Nayarit.

E - Selected interceptions from avocado fruit 1985-1992, Fruit from Mexico in passenger baggage, stores and mandado.

187 interceptions--Curculionidae, species of
82 interceptions--Conotrachelus aquacatae (Curculionidae)
73 interceptions--Stenoma catenifer (Oecophoridae)
29 interceptions--Conotrachelus perseae (Curculionidae)
10 interceptions--Heilipus sp. (Curculionidae)
9 interceptions--Conotrachelus sp. (Curculionidae)
7 interceptions--Tortricidae, species of -
7 interceptions--Tarsonemus sp. (Tarsonemidae)
6 interceptions--Gracillaridae, species of
4 interceptions--Gnathotrichus sp. (Scolytidae)
2 interceptions--Anastrepha sp. (Tephritidae)
1 interception--Apion sp. (Curculionidae)
1 interception--Marmara sp. (Gracillaridae)
1 interception--Platynota sp. (Tortricidae)
1 interception--Amorbia sp. (Tortricidae)

F - Assessment of Fruit and Seed Pests

1. Fruit flies

In general, avocado fruits are a poor host of Anastrepha and certain cultivars of avocado are believed to be immune to attack by these pests. The Mexican officials state that the cultivar that they want to export, "Hass", is not a host of Anastrepha. There is some evidence of this. APHIS believe that the evidence is not adequate to make a decision on host status.

There is no question that A. ludens and A. serpentina utilize at least certain cultivars of avocados as a host. ARS has reared the above two pests in numbers from avocados collected in the field in Mexico. Two comprehensive, current publications did not list A. striata in avocado, but a few older reports did. It is well known that the A. fraterculus population occurring in Mexico differ from the South American fruit fly including its host range. APHIS has considered the "Mexican A. fraterculus" different from the South American fruit fly when determining the entry status of certain fruits in the past.

Thus a reassessment of the last two pests has been completed, and the results are given below. The reported evidence indicates that APHIS should be concerned with A. striata with the import of Mexican avocado fruit. It is suggested here that APHIS not list A. fraterculus as a concern for avocados from Mexico. It is considered a different form or species than the South American fraterculus with a different host range. No records of the Mexican form has been reported from avocados (from Mexico or Central America) even though ARS has studied the relationship between avocados and fruit flies in the 1950's, and in light of various other studies of Anastrepha in the 1980's.

Anastrepha fraterculus

It has been suspected since at least 1942 that the fruit fly species "A. fraterculus" represents a complex of species. Stone (1942) noted that specimens from Trinidad, Panama and northward were morphologically different from specimens in its southern range. Stone stated that "it is possible that it will eventually be found to represent a complex...". Based both on morphology and differences in host utilization, Bush (1962) and Baker (1945) considered the Mexican form a distinct species from the South American A. fraterculus but did not rename it. The population has been since known as the "Mexican A. fraterculus". Recent isozyme analysis of eight populations done by Steck (1991) indicated at least two species and possibly more in this complex. He found that populations sampled from Mexico and Costa Rica were very

similar, and they were related to populations from northern Brazil and coastal Venezuela; but that these populations were distinct from ones from southern Brazil, the Venezuelan Andes and Peru.

Anastrepha fraterculus is reported as a pest of avocado in several papers (e.g. Ebeling 1959, Weems 1969, Norrbom 1988). After a review of these papers and of the papers that these authors cited, no record of A. fraterculus was found associated with avocado fruit from Mexico or Central America. When the authors reported a location of the infestation, it has been only for Argentina. In fact, Rust (1918) report of A. fraterculus larvae in fruit from northern Argentina may be the only primary host record for this pest attacking avocados and the direct or indirect source for all other reports.

Several recent projects in Mexico, Guatemala and Costa Rica concerned with the collection of fruit and the recovery of fruit flies from that fruit has provided additional information about the host/pest relationship within this genus but no new report of A. fraterculus attacking avocados.

In the mid-1950's, the ARS unit located in Mexico conducted a survey of the avocado areas of Mexico. Although the complete results are not available (no publication has been located except an unpublished March 1956 monthly newsletter and Bush (1957) which gave preliminary results), the following can be said. Avocados were collected from at least 27 growing locations in eight Mexican States (Michoacan, Jalisco, Guanajuato, Queretaro, Veracrus, Hidalgo, Puebla and Chiapas). The numbers of fruit collected at each site varied; 6,743 fruit from one or more locations in Michoacan, 900 fruits from Jungapeo, Michoacan, and 145 fruit from Atlixco, Puebla. They found that the most ideal altitude for collecting infested avocados was between 4,000 and 5,500 ft. They found avocados infested with A. ludens (i.e. 1853 flies reared from Michoacan fruit in 1957) and A. serpentina (48 flies recovered in fruit from Tapachula).

Anastrepha striata

This pest was reported to attack avocado fruit by Oakley (1950). Current papers (Wasbauer 1972, Norrbom 1988) do not list avocado as a host. Since these current papers are considered comprehensive, the Oakley report may be questionable. The Oakley paper cited a 1936 publication by Ballou as his only source.

This review discovered that Jiron and Hedstrom (1988) found that A. striata survives year round on the Caribbean slopes of Costa Rica by shifting among several hosts including avocado (Persea americana). Thus, we can assume that avocado is a valid field host for this pest.

Other fruit flies

Two other fruit flies are mentioned in literature as occurring in Mexico and attacking avocado. Ceratitis capitata, Medfly, which is known to attack avocado become established in Mexico in 1977 and was eradicated in 1987. Periodically outbreaks occur in southern Mexico in the State of Chiapas and are eradicated. Host material from areas where the outbreaks occur are regulated.

Anastrepha grandis was reported to attack avocado fruit and to occur in Mexico by Pollard (1984). This report was erroneous. More recent and/or comprehensive papers authored by fruit fly experts report A. grandis as occurring only in South America and not attacking avocado (Norrbom and Kim 1988, Norrbom 1991).

2. Other Fruit and Seed pests

Conotrachelus perseae and C. aguacatae (seed weevils)

a. Distribution - These seed weevils are reported to occur in Mexico and Central American as far south as Panama (Whitehead 1979, Ebeling 1959). In Mexico, C. perseae is reported for the States of Michoacan, Puebla, Veracruz, and Jalisco; C. aguacatae is reported for the States of Coahuila, Jalisco, Michoacan, Nayarit, Queretaro, Guanajuato, Puebla, and Morelos (Whitehead 1979 and Sanidad Vegetal 1992).

b. Host - The only host reported for C. perseae and C. aguacatae is Persea americana (avocado). Interception of Conotrachelus by PPQ indicate that the Mexican race of avocado seems to be most heavily attacked (USDA 1941). Sanidad Vegetal (1992) reports that the "creole type of avocados" (Mexican race) are preferred but the variety Hass is attacked by both of these weevils. Since Conotrachelus is reported as a pest of avocado in Central American, it should be assumed that various varieties of the Guatemalan race can be attacked.

c. Biology - Eggs are deposited on the young undeveloped fruit and the larvae feed in the seed until they are fully developed. When fully developed the larvae exit the fruit and pupate in the soil. Sanidad Veetal (1992) reports that from one to four larvae of C. perseae develop in each infested fruit. Sleeper (1979) reports that up to 28 larvae can be found in one fruit. Sanidad Veetal (1992) also states that the damaged fruit falls to the ground before the fruit is fully developed and Sleeper (1979) states that infested fruits usually fall to the ground. PPQ has intercepted larvae in various stages of development in avocado being smuggled into the United States which would indicate that at least a portion of the infested fruits developed to a marketable stage (USDA 1941). The adults are active at night and feed to at least some degree on the fruits, leaves, and stems of avocado trees.

In Mexico, Conotrachelus perseae is reported to have two generations a year.

d. Economic Importance - Ebeling (1959) ranked both of these weevils as minor pests of avocados. Sanidad Vegetal (1992) reported that on neglected farms that the infestation rate could be between 7 and 18 percent of the fruit and as high as 66 percent from creole trees. Field controls reported by Sanidad Vegetal include foliage and ground application of pesticides, raking of the ground to expose the pupae, and the collection and destruction of fallen fruit (Sanidad Vegetal 1992).

2. Heilipus lauri (a seed weevil)

a. Distribution - This pest is reported to occur from Mexico south to at least Colombia. In Mexico it is reported from the States of Hidalgo, Mexico, Morelos, Veracruz, Guerredo, Puebla, and Tlaxcala (Garcia 1962; Sanidad Vegetal 1992).

b. Host - Sanidad Vegetal (1992) reports that it prefers creole avocado tree (Mexican race) but also attacks improved avocado varieties.

c. Biology - Ebeling (1959) reports the biology of this pest. He states that there is one generation per year. The winter is spent in the adult stage and that the adults deposit eggs in the developing fruit in May, June, and July. The larvae tunnel to the seed where it feeds and pupates. After the adults leave the fruit they feed on the leaf, bud, sprout, and fruit of their host. Sometimes pupation takes place in the soil from fallen fruit. Sanidad Vegetal (1992) states that there is an average of two larvae per infested seed and that there was two generations in a 15.5 month period in Morelos, where this pest was studied.

d. Economic Importance - Ebeling (1959) ranked H. lauri as a major pest of avocado. In certain areas of Mexico it can cause up to 80 percent fruit loss (Garcia 1962). Sanidad Vegetal (1992) reported various field controls including foliage application of pesticides directed at the adults, weed control, and destruction of fallen fruit.

3. Stenoma catenifer (avocado seed moth)

a. Distribution - This pest is reported to occur from Mexico south to Brazil. In Mexico it is reported from the States of Veracruz, Tamaulipas, Oaxaca, Chiapas, Nuevo Leon, Guerrero, and Colima (Acevedo 1973).

b Host - This moth is reported to attack Persea americana (avocado), Persea schiedeana ("Chinini") and Beilschmedia sp. ("anayo") (Acevedo 1973, USDA 1980).

c. Biology - This moth spends the winter as an adult in the soil or leaf litter. In the spring the female mates and deposits eggs on the stem and fruit of its hosts. The larvae bores in the stems and fruit. Within the fruit it feeds on the seed. Pupation takes place in or on the soil. The number of generations per year varies depending on the availability of fruit (Acevedo 1973, Ebeling 1959, and USDA 1980).

d. Economic Importance - This is one of the most serious avocado pest in the world. Ebeling (1959) rates it as a major pest of avocado. The larvae damage the terminal twigs and can often kill young trees. The damage on stems can also result in fruit drop. The damage to the fruit makes in unmarketable. In Venezuela, it is considered one of the most important pest of avocado (Boscar and Godoy 1982). In tropical areas of Mexico, this pest is a limiting factor of avocado production. A fruit infestation rate of 94 percent has been reported. In one study, it requires 14 treatments of pesticide per season to eliminate damage from this pest (Acevedo 1973).

4. Copturus aguacatae (an avocado stem weevil)

a. Distribution - This weevil is known only from Mexico and in Mexico it is at least known to occur in the States of Guerrero, Puebla, Morelos, and Michoacan (Whitehead 1979, Kissinger 1957).

b. Host - The only host found reported was Persea americana (avocado) (Kissinger 1957, and Muniz 1959). Adults reared from smuggled avocado fruit intercepted on the Mexican border has been identified as this pest. In recent years hundreds of identical larvae have been intercepted in Hass avocado fruit intercepted by PPQ from Mexico mainly at El Paso, Texas.

c. Biology - The weevil borers into the small new stems, new branches, and can affect the older branches in high populations. Eggs are laid in the epidermis of the plant. A maximum of eight eggs are laid in a group by the female. Oviposition occurs mostly in April and May by the first generation and in October and November by the second generation, although adults emerged from May to early July and from November to February (Muniz 1959).

d. Economic Importance - This species and related weevils have been reported to cause great destruction to avocado trees. The boring of this pest causes die back of the branches and uncontrolled infestations can cause reduction in size of the tree. Ebeling (1959), Sleeper (1978), and Whitehead (1979) consider this a major pest of avocado. Other damages are caused by secondary infestations by bacteria, fungi, and viruses (Muniz 1959). This pest or related ones have been controlled with repeated foliage sprays with contact pesticides.

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ATTACHMENT #2 PATHOLOGY PERSEA MEXICO

A - THE FOLLOWING PATHOGENS ARE KNOWN TO ATTACK THIS HOSTS IN THE COUNTRY OR COUNTRIES LISTED BELOW.

1 Phyllachora gratissima REHM
- RED-BROWN LEAF SPOTS ON Persea americana (Watson, 1971)
- OCCURS IN MEXICO (WATSON, 1971)

2 Radopholus similis (COBB) THORNE
- BURROWING NEMATODE IN Persea americana (FAO, 1986)
- OCCURS IN MEXICO (MEXICO, 1976)

3 Rosellinia bunodes
- BLACK ROOT ROT OF Persea americana (C.M.I. DES.)
- OCCURS IN MEXICO (WATSON, 1971)

B - References

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C - Previous decisions

Central America:
Prior to 1961 avocados were permitted entry into New York. This authorization was expanded after 1932 to include entry to other North Atlantic ports, at North Pacific ports and at New Orleans for transit movement to Northern areas. In 1961 a decision was made to deny entry of avocado fruits because of a complex of internal feeding insects.
Jamaica:
1965 - Permitted entry into all ports subject to inspection.
Mexico:
1988 - Denied entry for leaves because of complex of diseases.

D - Interceptions of pathogens (1971 - 1988)

Sphaceloma perseae - 7 times
Phomopsis sp. - 6 times
Coniothyrium sp. - 4 times
Diplodia sp. - 3 times
Ascochyta sp. - 1 time
Phoma sp. - 1 time
Cladosporium sp. - 1 time
Septoria sp. - 2 times
Phyllachora sp. - 1 time
Phyllachora gratissima - 2 times
Macrophoma sp. - 1 times

E. Assessment FY 1985-90:

Additional interception of some of the above genera/species were made but no new disease interceptions.

Pathogens:

Phyllachora gratissima Rehm. - on leaves in Mexico, and parts of Central America, So. America, and the Caribbean.
Phyllachora maculicola chardon - on leaves in Guatemala and Honduras.

Additional information:

Spaceloma perseae occurs in Southeastern U.S. and causes visible scabs on the fruits.

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